

Omnidirectional Vehicle

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The July/August 1983 Patent Probe struck a responsive cord. That column looked at patent number 4,258,815 for an Ambulatory Platform. Many people called or wrote for further details about this invention. The Ambulatory Platform is one of several highly-maneuverable wheeled vehicle patents found in the files of the United States Patent and Trademark Office. An earlier example of this type of vehicle is patent number 4,237,990 issued to Hau T. La on December 9, 1980.

From Toys to Wheelchairs. The patent discloses an "Omnidirectional Vehicle" provided with three individually-driven wheels rotatable on horizontal axes. The invention may be used in a passenger carrying vehicle. Such a vehicle can be used as an amusement bumper car or a protectively shielded car for moving around in a hot cell. Remotely controlled toys or game pieces can also use the three-wheeled system. The high maneuverability allows such toys to move easily into spaces on a game board. The patent, however, is specifically described in terms of a wheelchair for physically handicapped persons.

The La invention uses three wheels, each placed at the corner of a triangle. One wheel's axis forms an angle with another wheel's axis. A vehicle using the La system has true omnidirectionality and directional stability. True omnidirectionality is the ability of a vehicle to move in any direction or to rotate about any point on a given surface without sliding. Directional stability is a characteristic of plural-wheeled vehicles in which there exists only one possible vehicle motion for every given set of wheel rotations.

Variable Roller Configurations. Figure 1 shows a wheel which has eight spokes radiating from a central hub. Eight rollers are mounted around the wheel's periphery. Each roller has an arcuate surface which conforms to the wheel. There will be some bouncing as the rotating wheel rolls from one roller to the next. The rollers are made of rubber to provide traction and dampen

the bounce. More than eight rollers can be used, but of course the expense of construction will increase.

Figure 2 shows an alternative roller configuration which eliminates the bouncing movement of the wheel of figure 1. The rollers are mounted at an angle of about

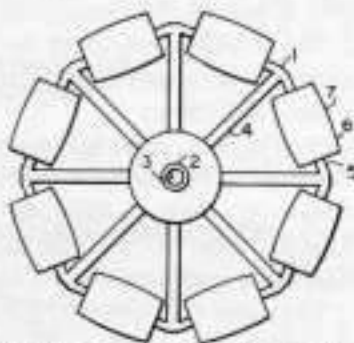


Figure 1: A front elevational view of a wheel defined by the La patent.

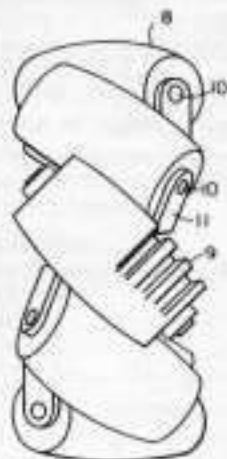


Figure 2: A modification of the roller mounting. Each roller is mounted at an angle with respect to the wheel's axis.

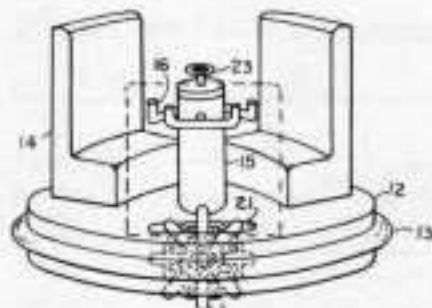


Figure 4: A perspective view of a bumper car. One seat has been removed to show how a wheel is positioned.

45 degrees with respect to the wheel's axis. As one roller leaves the ground, the next roller makes contact.

Three-seat Bumper Car. The bumper car shown in figure 4 is composed of a circular platform (12) surrounded by a resilient bumper ring (13). Three inwardly facing seats (14) are mounted to the platform. Three control handles (16) are mounted to a central post (15). These handles move potentiometers for controlling the action of drive motors for each of the three wheels.

The drive motors (19) are shown schematically in figure 5. Each wheel is mounted

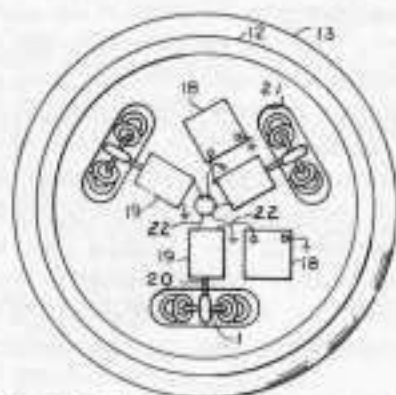


Figure 5: A bottom view of the bumper car with the drive motors, battery, and controls shown schematically.

to the respective shafts of the three motors. The platform can include cut-outs (21) to provide clearance for the wheels. Each wheel would then extend up through the cutout into a hollow space under each seat. Electrical wiring from the batteries (18) and the motors extend up through the central post and are connected to the control potentiometers.

The bumper car motion is related to the rotational speed of the wheels by the equations:

$$\begin{aligned} r\omega_1 &= v_x + R\omega \\ r\omega_2 &= -0.5v_x + 0.866v_y + R\omega \\ r\omega_3 &= -0.5v_x - 0.866v_y + R\omega \end{aligned}$$

Using an orthonormal coordinate system of axes fixed with respect to the body of the vehicle and in the plane of the platform, the variables are defined as follows:

- v_x and v_y are respectively the x and y components of the translational velocity of the vehicle
- ω is the rate of rotation of the vehicle around its center
- $\omega_1, \omega_2,$ and ω_3 are the rates of rotation of the three wheels
- r is the wheel radius
- R is the distance from the center of the vehicle to the center of the wheel

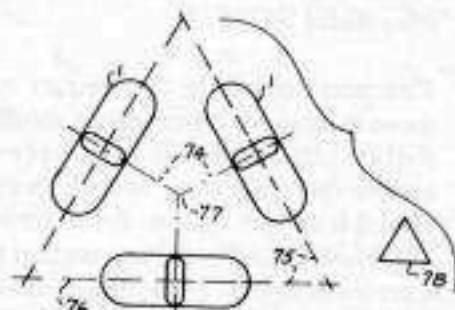


Figure 11: Schematic diagram of the footprint is shown which corresponds to the wheel system of figure 1.

If the wheels are of equal radius and equidistant from the center of the vehicle, r and R will be the same value and will simplify the equations. The system of coordinates is chosen so that the origin lies at the center of the vehicle. The center of one wheel is chosen to lie on the negative y axis. This places the second wheel in the first quadrant (+x, +y). The third wheel will then be in the second quadrant (-x, +y).

If the x, y, and z output voltages of the potentiometers have the same range of

values, the wheel drive motors may be controlled by relating their drive voltages as follows:

$$\begin{aligned} V_1 &= V_x + 0.5V_z \\ V_2 &= -0.5V_x + 0.866V_y + 0.5V_z \\ V_3 &= -0.5V_x - 0.866V_y + 0.5V_z \end{aligned}$$

In the circuit of figure 14, slider 64 on resistor 62 is connected through a resistor to the negative terminal of the operational amplifier 92. The operational amplifier 92 is configured as a unity gain inverter by means of a feedback resistor. The positive input terminal is grounded. A power supply is connected to the amplifier in such a way that terminal 96 is at a potential of +15V while terminal 97 is at -15V with respect to ground. With such a configuration, the amplifier will invert the input voltage V_x as required to satisfy the algebraic relationship.

Slider 64 is also connected via a resistor to the negative terminal of an operational amplifier 71 which provides the drive voltage V_1 . Slider 65 is connected via a resistor to the negative terminal of amplifier 102. The output of amplifier 92 is via 200k ohm resistors to amplifiers 72 and 73. Slider 64 is further connected via a 115.5k ohm resistor to terminal 106. Terminal 103 is connected by a 115.5k ohm resistor to terminal 107.

In addition to the translational voltages $V_1, V_2,$ and V_3 , a rotational component is added to each voltage by action of slider 69. Slider 64 is connected by 200k ohm

resistors to terminals 99, 106, and 107 respectively.

Further Reading. Other highly maneuverable vehicles have been proposed. Some of these prior vehicles are exemplified by the following U.S. patents: 3,789,947, "Omnidirectional Wheel," to Blumrich; 3,253,632, "Resilient Wheel," to Dalrymple; 1,305,535, "Vehicle Wheel," to Grabowiecki; 3,876,255, "Wheels for a Course Stable Self-Propelling Vehicle Movable in any Desired Direction on the Ground or Some Other Base," to Ilon; 3,295,700, "Method and Apparatus for Handling Radioactive Materials," to Ziegler; 3,465,843, "Vehicle with Improved Steering Device," to Guinot; 3,746,112, "Directionally Stable Self-Propelled Vehicle," to Ilon; 3,420,326; "Land Vehicle Propulsion," to Kusmer; and 3,570,615, "System for Controlling the Application of Motion of Vehicle Wheels," to Guilbaud. □

Copies of Patent 4,237,990 and the other patents mentioned are available from the U.S. Patent and Trademark Office for \$1.00 each. Orders for patents should be sent with payment to: Commissioner of Patents and Trademarks, Washington, DC 20231.

The illustrations in "Patent Probe" are reproductions of diagrams in the original patent documents.

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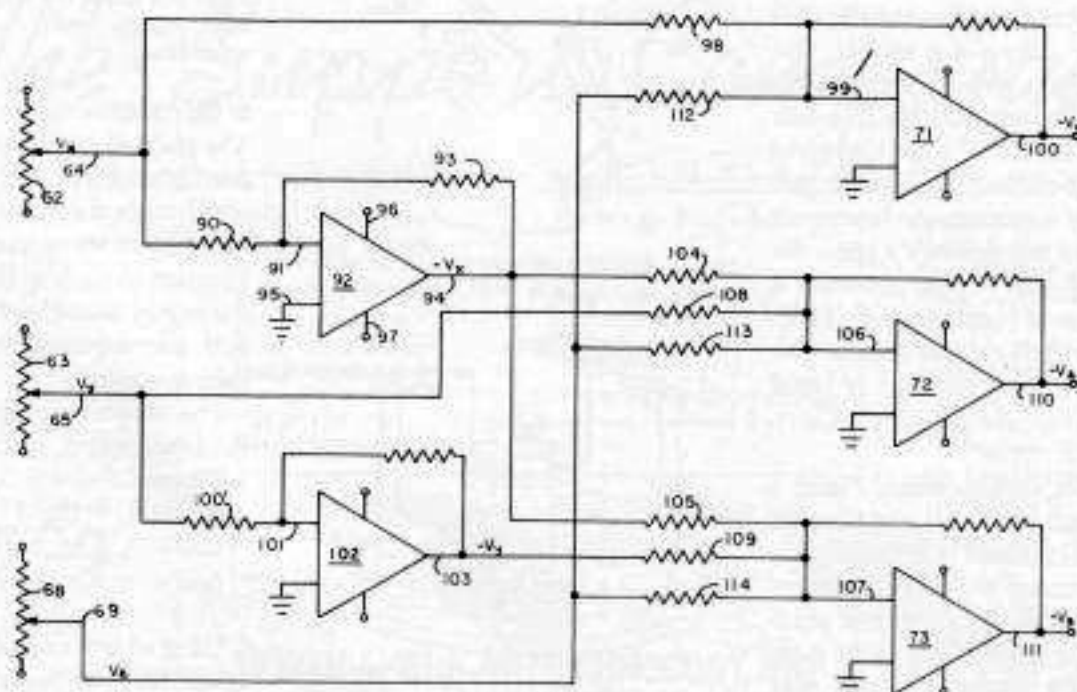


Figure 14: A detailed schematic of the control circuit for the three-wheeled vehicle.